POR-2033(EX)
(WT-2033)(EX)
EXTRACTED VERSION

OPERATION DOMINIC

CHRISTMAS AND FISH BOWL SERIES

PROJECT OFFICERS REPORT — PROJECT 7.1

ELECTROMAGNETIC SIGNAL, UNDERWATER MEASUREMENTS

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NOTICE:
This is an extract of POR-2033 (WT-2033), Operation DOMINIC, Christmas and Fish Bowl Series, Project Officers Report, Project 7.1.

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ABSTRACT

Kaman Nuclear conducted tests under Project 7.1 with the objective of obtaining measurements of the electromagnetic (EM) signals from nuclear detonations at large distances from the detonation point, above and beneath the sea surface. The planned use of the data is that of determining the feasibility of an Indirect Bomb Damage Assessment (IBDA) system based on the nuclear EM signature.

The tests completed under Project 7.1 have provided experimental data useful to the above requirements. One of the primary tasks accomplished was a determination of the actual distortion of the EM transient signal as it propagates down through sea water. This is important because the sea water has a conductivity and phase shift that is frequency dependent for VLF signals. The resulting data demonstrates this distortion of the highly complex EM signal and will help define the limits and desirable specifications for a practical, operational, Polaris-EM-IBDA system.

The specific tests were conducted from two ships. One ship had a calibrated, above-water, whip antenna plus an underwater long wire (standard submarine type) antenna. The other ship had an identical installation, except that the underwater antenna was a 6- by 6-foot loop antenna set at various depths. Broadband video outputs from these four antennas were presented on scopes and photographed and recorded on magnetic tape.

The EM signatures recorded both above and below the water surface for the various nuclear events are unique, recognizable, and predictable to a useful degree. It appears entirely feasible to utilize this nuclear EM signal as a method of IBDA.

The significance of the data presented herein lies primarily in the demonstrated ability to detect an above-water EM signal with an underwater antenna system. Signal characteristics are changed in magnitude and phase but are very easily recognizable with but a minimum of measuring equipment.

Reliability of the data taken on film records is considered to be good because of the instrumentation and calibrations used. The initial portion of the signal was lost on the majority of the signals due to triggering difficulties, but the maximum amplitude and phase relationships were recorded.

CHAPTER 2

PROCEDURE

2.1 OPERATIONS

2.1.1 Shot Participation. Participation in all the shots of Operation DOMINIC was planned. Table 2.1 lists shots along with pertinent information. Included in the table are the pre-shot estimates of expected EM signal strengths at the test site (see Section 2.2.2).

2.1.2 Test Site Activities. The primary activity at the test site consisted of cruising on-station within 100 miles of Oahu and recording EM signals as scheduled. In pre- and post-shot intervals, calibrations were made, and atmospheric noise was recorded. Considerable time and effort were directed toward establishing communications with proper sources in order to coordinate ship movements and shot recording times.

2.2 INSTRUMENTATION

2.2.1 Test Site Installation. The installation for these tests consisted of two stations on ships cruising at slow speed in the coastal deep waters south of Oahu. The ships, operating as Task Element 8.3.6.6 were the minesweepers MSO-457 LOYALTY and MSO-456 INFLICT. Each vessel was outfitted with antennas both above and

CHAPTER 3

RESULTS AND DISCUSSION

Data was successfully recorded on 22 of the 26 shots listed in Table 2.1 which produced EM signals. Of the four shots for which no data was obtained, one (Tanana) had such a low yield that the signal could not be detected in the presence of the high noise level* at the test site at the time. A second shot (Star Fish Prime) completely saturated recording equipment so that no definable trace was obtained. Two shots (Aztec, Sunset) were not recorded because of miscoordination in communications about event timing.

The film data on 13 of the 22 recorded shots has been used to calculate field strengths of the EM pulses. Insufficient scope deflection, loss of calibration data, or improper triggering of the scope sweeps caused nine film records to be unreliable with respect to data analysis.

Since the tape recorders used were of low quality in phase and amplitude response in the desired frequency

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*Loran station within line of site in bay where we sought shelter after experiencing 57°-roll weather!

Using these same examples, the computations were performed as follows:

TRUCKEE Depth/phase measurements

Estimated depth: 2 fathoms to top of loop plus rigging spacers

NPM phase measurements: inverted loop at depth phase lag, 35 μsec. Inherent loop fixed delay: 1.66 μsec. The actual phase delay was, therefore, 33.34 μsec.

Underwater phase velocity = 22 x 10^4 m/sec

= 0.22 m/μsec

Effective delay depth = 7.34 meters at 19.4 kc to electrical center = 23.4 ft ≈ 3.9 fathoms

Shot Signal phase measurements:

Effective frequency: 5000 cps

Loop at depth phase lag: 80 μsec

Fixed delay: 1.66 μsec

Actual delay = 78.34 μsec

Phase velocity: 0.10 m/μsec

Effective delay depth 7.834 meters at 5 kc

SWANEE Depth/phase measurements

Estimated depth: 2 fathoms ±3- to 6-ft wave motion (14 ft wave maximum). Inverted signal due to direction of loop.

First signal t_1 (peak(pos)loop) - f_1 (peak(neg)whip)=

33.6 minus 1.66 μsec = 32.0 μsec

Third signal t_3 - f_3 = 38.5 minus 1.66 μsec =

36.84 μsec

Effective frequency cross-over time

1 to 2-46.8 μsec = 11 kc

2 to 3-53.7 μsec = 9.2 kc

Phase velocity = 0.166 m/μsec at 11 kc

= 0.150 m/μsec at 9.2 kc

v x t = effective depth

(at 11 kc): 0.166 x 32 = 5.3 meters (17 feet)

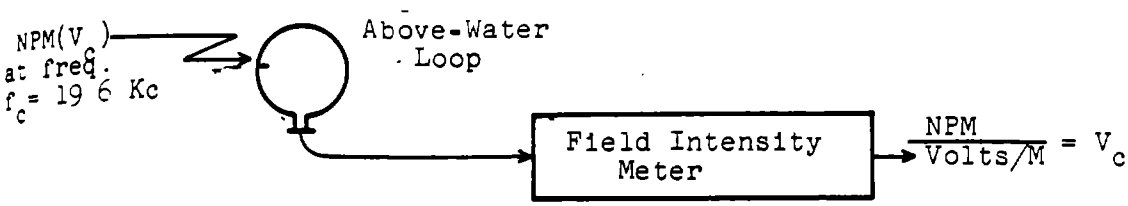
(at 9.2 kc): 0.150 x 36.8 = 5.52 meters

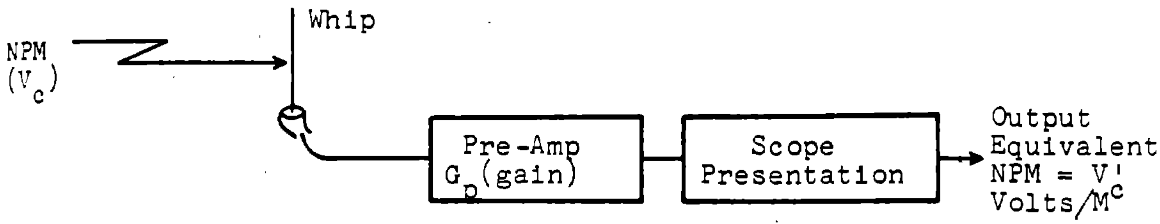
TABLE 3.1 SUMMARY OF RECORDED EM PULSE DATA

On the tape records, the upper and lower traces are misalined due to the tape recorder. If data was recorded, the figure number of the reproduced signal is listed. If data was not recorded, NR is listed.

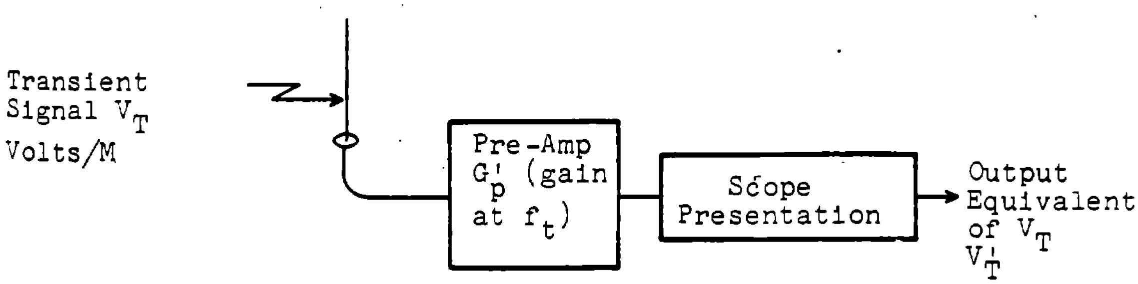
Due to the triggering level differences between the two ship records, a direct corresponding time comparison is not evident from these records by a casual visual inspection. Also, the apparent high-frequency peaking due to the 1,000-foot wire is evident in some USS INFLICT records.

Shot Name	Station				Shot Name	Station			
	USS INFLICT		USS LOYALTY			USS INFLICT		USS LOYALTY	
	Film	Tape	Film	Tape		Film	Tape	Film	Tape
Aztec	No data recorded				Alma	3.10	3.29	3.10	3.29
Adobe	3.2	3.20	NR	3.20	Truckee	NR	3.30	NR	3.30
Arkansas	NR	3.21	NR	NR	Yeso	3.11	3.31	3.11	3.31
Questa	NR	3.22	NR	NR	Harlem	3.12	3.32	3.12	3.32
Frigate Bird	3.3	3.23	NR	3.23	Rinconada	3.13	3.33	3.13	3.33
Yukon	3.4	3.24	NR	3.24	Dulce	3.14	3.34	3.14	3.34
Mesilla	3.5	3.25	3.5	NR	Star Fish	Shot failed			
Muskegon	3.6	NR	3.6	NR	Petit	3.15	3.35	3.15	3.35
Sword Fish	Underwater shot, no signal				Otowi	3.16	3.36	3.16	3.36
Encino	NR	NR	NR	3.25	Bighorn	3.17	3.37	3.17	3.37
Swanee	3.7	3.26	3.7	3.26	Bluestone	3.18	3.38	3.18	3.38
Chetco	3.8	3.27	3.8	3.27	Star Fish Prime	Signal saturated equipment			
Tanana	High level noise interference, no signal				Sunset	NR	NR	NR	NR
Nambe	3.9	NR	3.9	3.28	Pamlico	3.19	3.39	3.19	3.39
Blue Gill	Shot failed								





$$\frac{\text{Scope Volts x cm}}{\text{cm}} = V'_c$$



Freq. Gain Correction* $\left(\frac{G'_p}{G_p}\right) \times \frac{\text{Scope Volts}}{\text{cm}} \times \text{cm} = V''_T$

then $\frac{V''_T}{V'_c} \times V_c = V_T$ Volts/Meter of the Transient Signal

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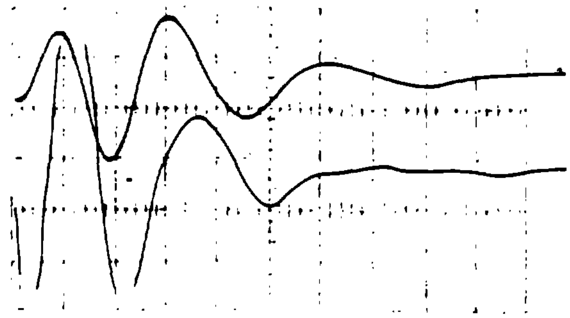
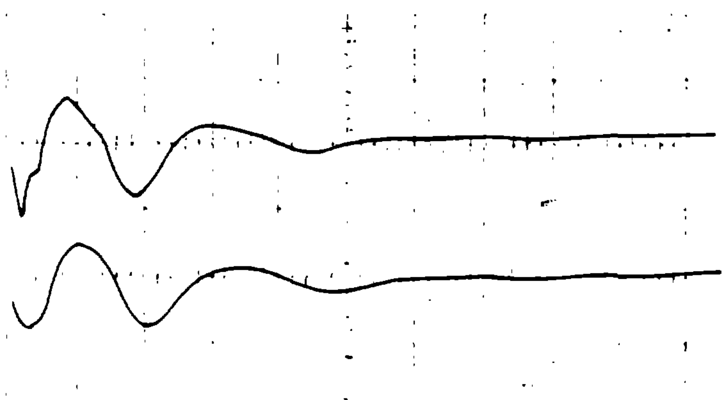
*See Figure 2.5. This illustrates that the preamplifier was sufficiently flat so that $G'_p/G_p \approx 1.2$.

Figure 3.1 Schematic representation of calibration consideration (above water).

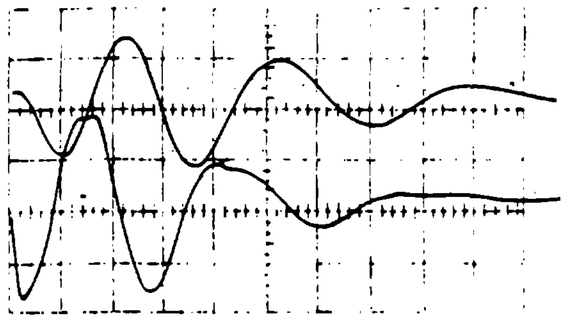


RINCONADA — LOYALTY
UPPER (LOOP) 3.2 V/ M
(23 TURNS 8 FT. DEPTH)
LOWER (WHIP) .8V/ M
SWEEP SPEED 50 μsec/cm



RINCONADA — INFLICT
UPPER (WIRE) 1.35 V/ M
LOWER (WHIP) .92 V/ M
SWEEP SPEED 50 μsec/cm

Figure 3.13 Experimental signal, film, Shot Rinconada.



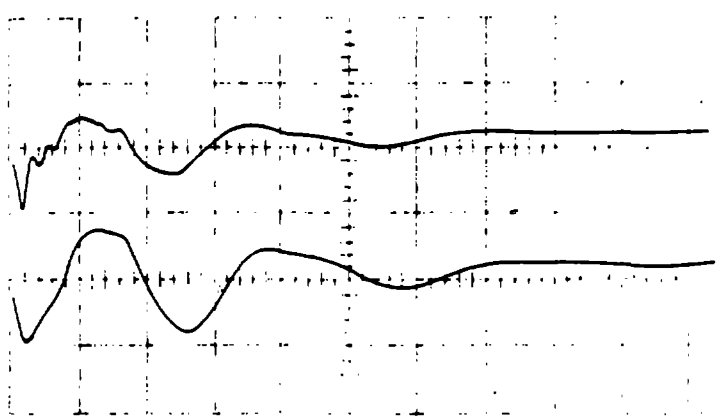
BIGHORN – LOYALTY

UPPER (LOOP) 1.95 V/ M

(23 TURN LOOP 8–10 FT. DEEP)

LOWER (WHIP) 1.4 V/ M

SWEEP SPEED 50 μsec/cm



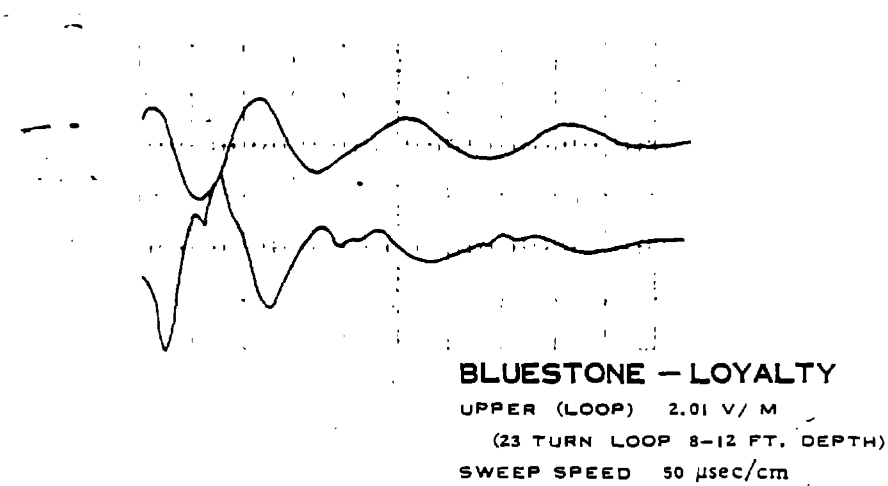
BIGHORN – INFLICT

UPPER (WIRE) 2.26 V/ M

LOWER (WHIP) 1.56 V/ M

SWEEP SPEED 50 μsec/cm

Figure 3.17 Experimental signal, film, Shot Bighorn.



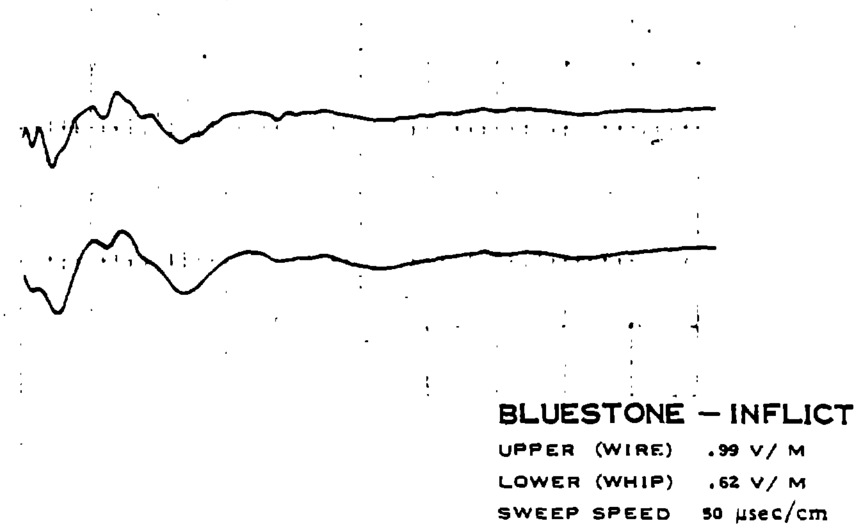


Figure 3.18 Experimental signal, film, Shot Bluestone.

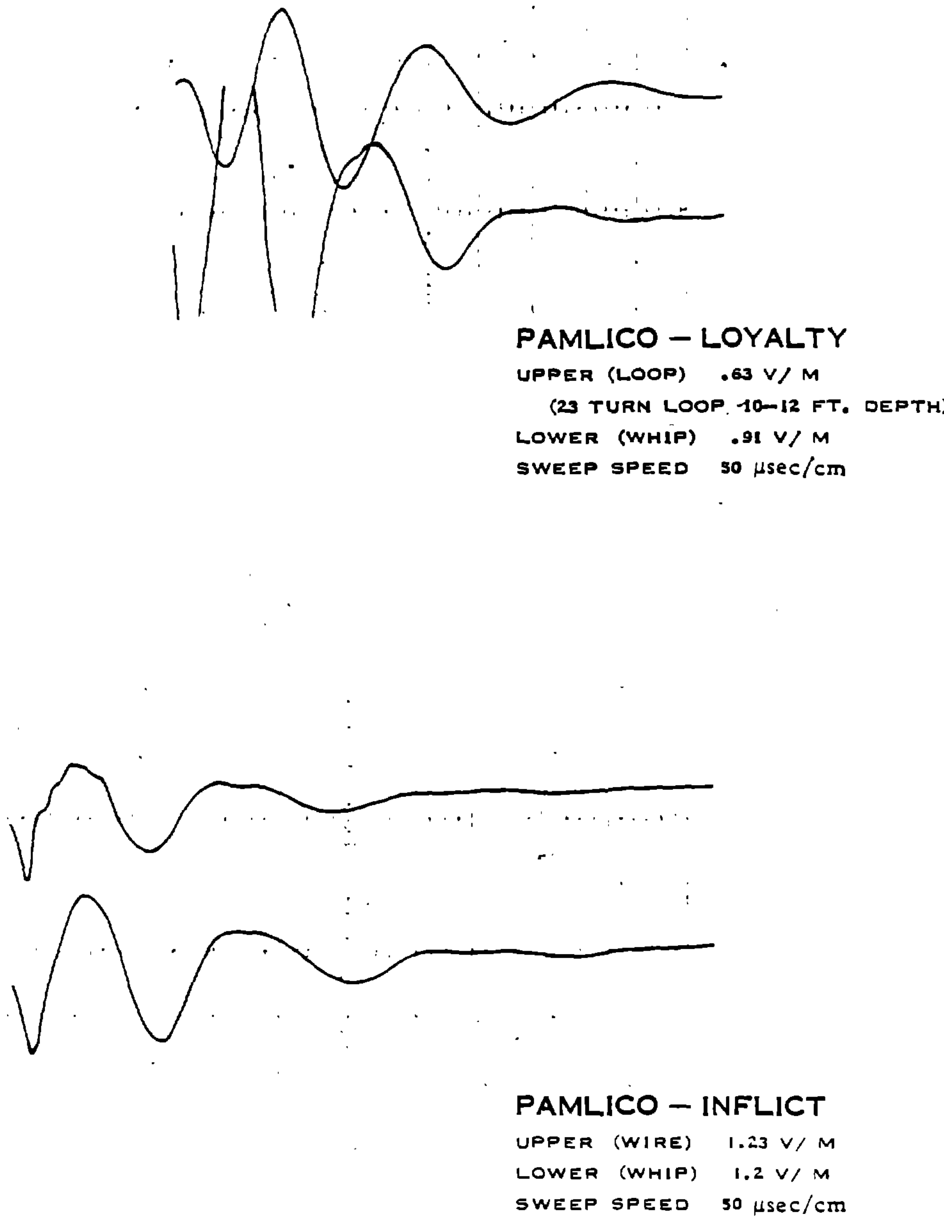


Figure 3.19 Experimental signal, film, Shot Pamlico.

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